

“EMERGENT DIGITAL DESIGN STRATEGIES IN ARCHITECTURE: TOOLS AND METHODOLOGIES”

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SUMMARY

The emergence of digital tools in architecture since the beginning of the XXI century is deeply transforming the protocols, the design methodologies, and the conceptualization of the discipline. Traditional architectural education has remained at the periphery of these developments, whereas certain “advanced” architectural schools are deploying tremendous efforts to embrace these tools. However, their embedment into pedagogical practice is not devoid of problems and inconsistencies.

This paper explores how several digital tools are being actively incorporated into the curriculum at the Institute for Advanced Architecture (Iaac) in Barcelona. It features relevant examples of urban design projects developed during three distinctive architectural design studios: two at the undergraduate level and one masters degree program.

Several digital tools currently available for architectural analysis, design, and representation are explored, with an objective to identify and propose their suitable implementation in current and future architectural design studios. It establishes how they might affect design methodologies, as well as identifying problems, challenges, and potentials.

Key words: Digital Tools, Real Time Data, Modelling Software, Digital Fabrication.

1 Introduction of digital tools into architectural practice

The vast advancements brought by the information society at the end of the 20th century is unquestionably affecting all areas of knowledge.ⁱ Perhaps some of the biggest transformations across many disciplines can be attributed to the extensive use of digital tools, the easy access to information, and the newfound capacity to access and to generate data.

A variety of digital tools are increasingly being used in the field of architecture during different stages of the project, accompanied by a rapid development rate of various software options. The use of digital tools in architecture dates back to 1980's (Fig.1), ranging from a digital version of traditional drafting techniques (such as AUTOCAD); including 3D modelling (Sketch-up, Rhino, Revit, 3D Max, Archicad); to the recent appearance of generative design software involving scripting and parametric design.

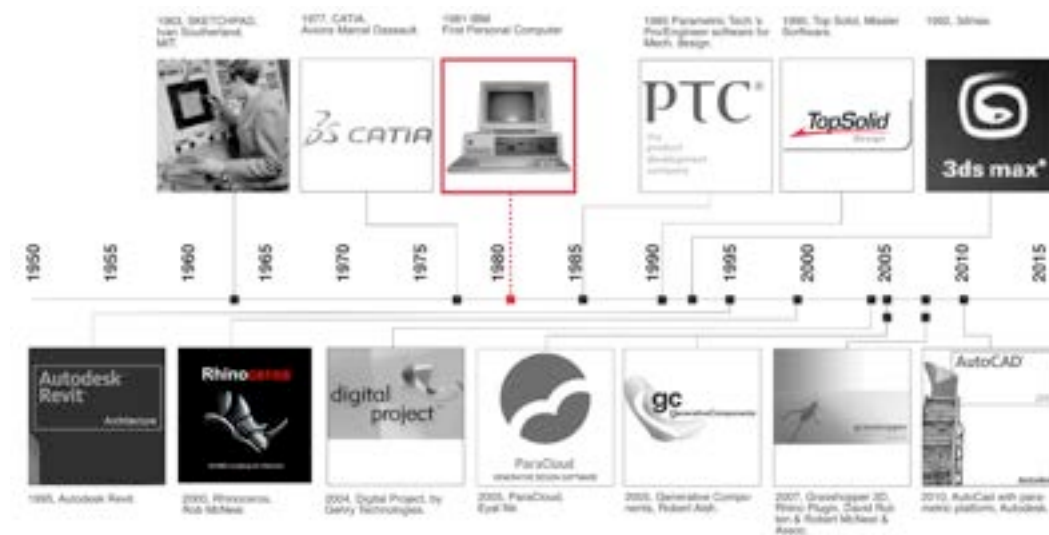


Figure 1. Digital tools in architecture from 1960-2015. Scheme showing digital platforms pre-digital and after the generalized dissemination of personal computers. Source: Maite Bravo, 2014.

Architectural practice is actively embracing digital tooling and methodologies as a strategic part of the project development, leading this transformation by pushing design innovation as a core objective in their proposals. Many architectural firms have established internal research units to further investigate their insertion into practice.

However, traditional architectural education has remained somehow at the periphery of these important developments, exhibiting some resistance towards the adoption of these innovative digital tools. Academia, once the leader and promoter of architectural advancement, nowadays seems to struggle to keep up with these changes, thereby the suitability of current architectural education, the preparedness of architectural graduates for practice, and the current academic theoretical discourse is under scrutiny.

In light of these developments, certain architectural schools are embracing the appearance of digital tools as a new found capacity for architecture, which can be conceptualized under the term “advanced architecture” (Gausa et al, 2001).ⁱⁱ

However, the embedment of digital tools into pedagogical practice is not devoid of problems and inconsistencies.

The following chapters focus around strategies for innovation in academia, implemented in one of the “advanced” architectural schools (IAAC) within two urban design studios: (Undergraduate and Master Program) ⁱⁱⁱ.

2 Design Studios: Resources, Protocols and Methods.

Each 3-month studio was based on the advanced architecture design approach, executing intensive research and design at the shrewd intersection between technology and environment, especially under the rubric of ecology and computational design. The objective was to continue with the school research agenda, using Barcelona as an experimentation laboratory and seeking innovative ways to improve this connection through speculative design. Challenged with the necessity for self-sufficient public space and infrastructure of future cities, the studios examined the relationship between urban territories and water along the Besos River, proposing unique interventions that can have profound impacts not only on local surroundings, but that can be applied on any context with similar issues.

A precise design methodology protocol was established during the project development, with distinctive steps: 1) Site Analysis; 2) Design Proposal/ Implementation; and 3) Design Simulation/representation. Although not mandatory, the use of a variety of digital tool was highly recommended during each one of these stages, and the students could choose the programs that best suited their skills and knowledge. Software training was provided during the development of the studio for Rhino, including plug-ins such as Grasshopper, Vasari and Heliotrope.

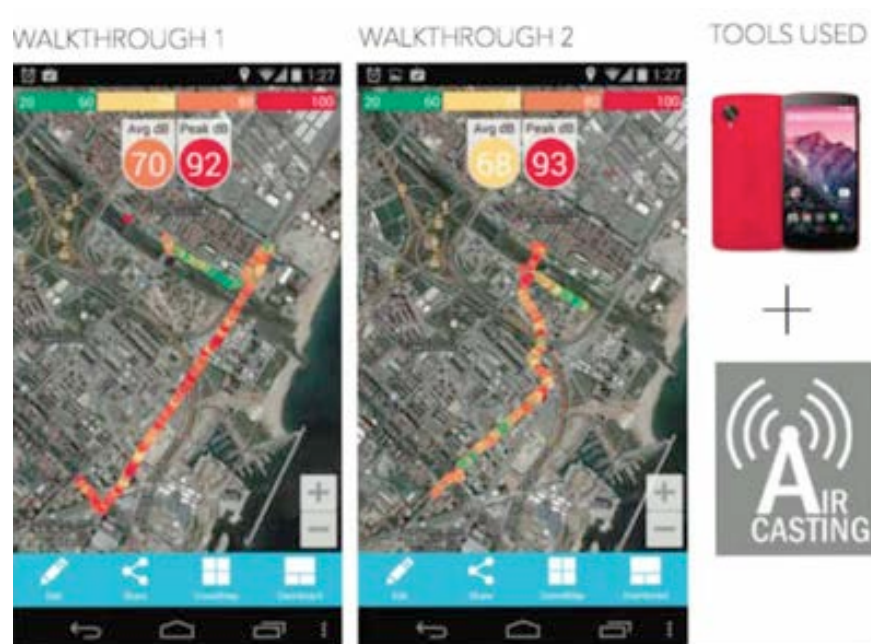


Figure 2. Site analysis showing data collection protocol for sound measurement levels in decibels, using Android recording app and AirCasting, CIEE Global Architecture + Design Institute for Advanced Architecture of Catalonia. Source: Vishaal Dokras + Katy Marino, Fall 2014.

During the first stage of site analysis, students detected phenomena to investigate, given that it could be measured and exhibit noticeable variations through the use of specific instruments. They defined a data gathering protocol based on a preliminary working hypothesis, exploring various techniques and digital tools to study their particular urban phenomena. They also had to select suitable digital tools to find and record site specific and context-related data to provide precise information (Fig 2).

The data obtained was later analyzed, classified, processed and evaluated. Students had to simulate models of the collected fluctuating data using novel mapping techniques, by means of free software plug-ins and online training communities, preferably through projection onto a 3D physical model. Among the modelling tools used were Rhino (including plug-ins such as Grasshopper, Galapagos, Heliotrope), Vasari (Fig 3), Ecotect, Maya, 3D Max, etc. Afterwards, conclusions about the site were extracted.

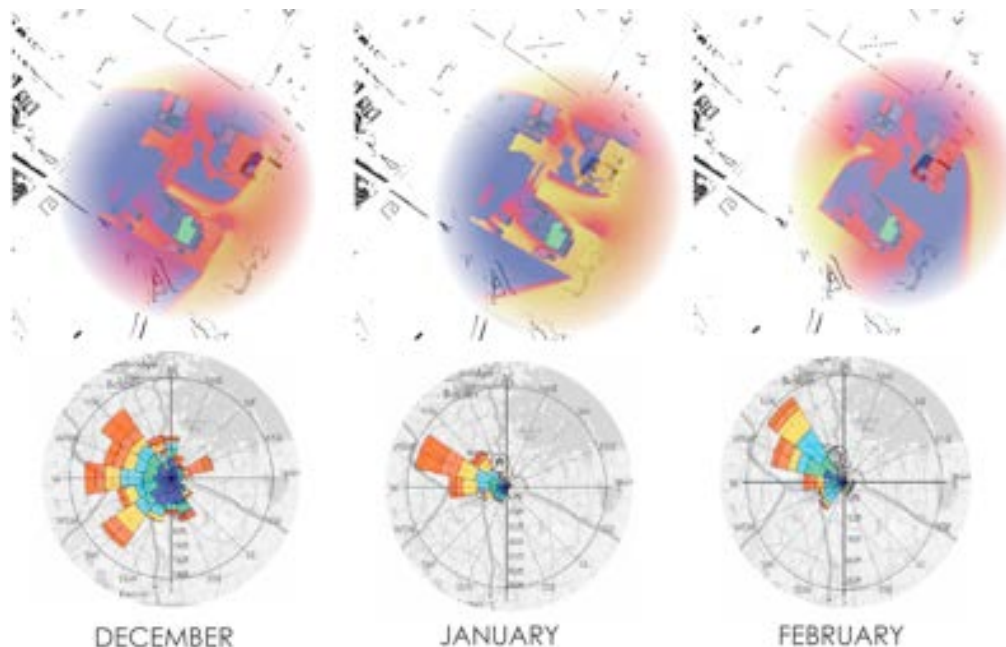


Figure 3. Site Analysis showing data simulation of wind conditions during December, January and February, with Vasari software. CIEE Global Architecture + Design Institute for Advanced Architecture of Catalonia. Source: Jose Dengel Mestres, Isabel Michaelides, Winter 2015. (update).

During the design proposal stage, suitable modelling tools based on available software were extensively explored. In reaching these goals, the studio deployed computational tools within the realm of digital design, using Rhino and Grasshopper for parametric and topological 3D modelling, animation and stereoscopic rendering, thus presenting concepts in enhanced 3D visualizations. Students applied the data gathered to formulate parameters for the derivation of forms with precise inputs and outputs, having the capacity to be responsive to local conditions. Students had to clarify the critical relationship between part-to-whole in design systems and the use of parametric design, optimizing according to given parameters; the use of software for simulation and evaluation, formulation of inputs, device and outputs, deploying system onsite with variations (time, data, etc).

Finally, the design simulation/representation stage was seeking to follow a precise strategy, where the site deployment showed how data is modified with the implemented solution proposing intervention of the phenomena analyzed. This last stage shows data gathered (input); and responses (output). They also had to define suitable digital fabrication techniques for prototyping, including the preparation of 3D models which would communicate with a variety of machines used in fabrication. The students worked in parallel with in-house 3D printers, laser cutters, and CNC machines, to produce physical models or prototypes.

3 Design Studio Outcomes

The projects developed during these studios can reveal several issues at each stage of the project development. During the site analysis phase, the phenomena investigated included: sound; luminosity; water-flows; wind; microclimates related to temperature and humidity; pedestrian flows; and pollution of both air and sound.

The tools selected to collect data were open source, simulation, or self generated. These tools included, but were not limited to: Smart Citizen Sensor (open source tool developed at Iaac); open data environments; self-generated tools (rudimentary self made tools were also acceptable); easily available apps; geographical information systems, etc.



Figure 4. Site Analysis showing data collection protocol (left) using digital tools (right): Anemometer, Smart Citizen Kit, and Iphone App. CIEE Global Architecture + Design Institute for Advanced Architecture of Catalonia (IAAC). Source: Addison Kleinbrahm, Eli Stirling, Winter 2015.

The most used tool was the Smart Citizeniv sensor (90% of cases), due to their easy use and availability, which collects data for temperature, humidity, light, noise, CO (carbon monoxide) and NO₂ (nitrogen dioxide) levels. Other tools for study included the “Aircast” decibel monitor application for sound recording, “Free Android SenseView App” for luminosity readings, purchased anemometers for wind direction and speed, self-made water flow apparatuses for the video recording of flow direction and speed, and self-made pedestrian flow apparatuses to record time and trajectory through a mix of chronometer, gps, and video recording.

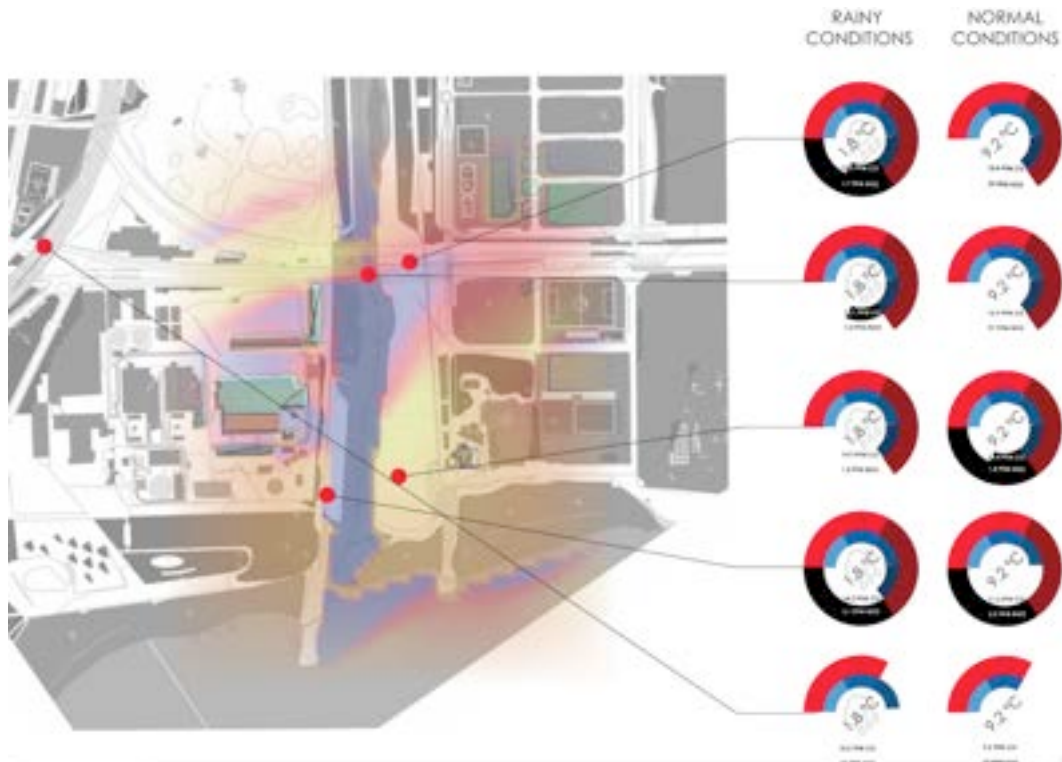


Figure 5: Site analysis stage featuring data representation showing pollution of CO and NO2 index related to humidity and temperature. CIEE Global Architecture + Design Institute for Advanced Architecture of Catalonia. Source: Jose Dengel Mestres, Isabel Michaelides, Fall 2014.

The data classification and processing stage involved various strategies, including: frequency/time mapping (sound), colour coded mapping (luminosity), NDVI reading map (vegetation analysis), diagramming (water flow), Autodesk Maya fluid simulation (wind flow), temperature-humidity mapping (thermal comfort), and dynamic mapping to show fluctuations over time (pollution).



Figure 6: Site Analysis Stage featuring data mapping representation. Sound recorded at certain coordinate expressed in frequency-time. CIEE Global Architecture + Design Institute for Advanced Architecture of Catalonia. Source: Vishaal Dokras + Katy Marino, Fall 2014.

The data representation was mainly implemented as digital simulation through projection mapping (Fig 7). The main topics include luminosity (Senseview - CSV file output - CSV read in Grasshopper - Data Simulation in Rhino); sound (App measures decibels Sound recording app, Aircast for decibels, Frequency mapping, Sound mapping reverberation); water-flows (map of pattern for movement around obstacles). The data collected was finally evaluated in the form of conclusion diagrams.

The design implementation involved parametric design using digital modelling software Rhino & Grasshopper.

In terms of digital fabrication, the majority of the projects used the Ultimaker 3D printer with 3mm biodegradable thermoplastic polymer filament. Some students used the laser cutter machine with 5mm plywood or 0.5mm plakene.

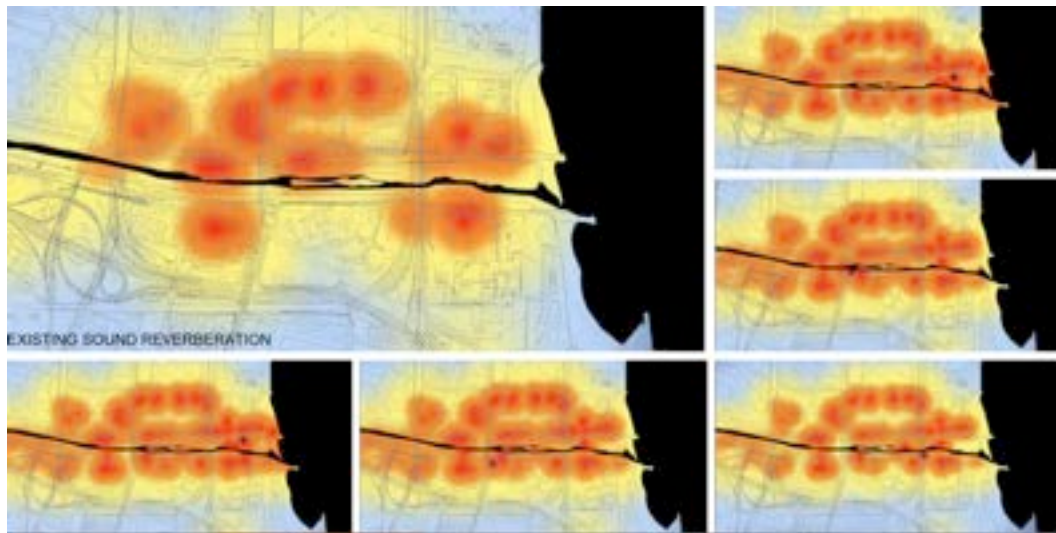


Figure 7. Site analysis Stage showing data mapping representation during showing sound levels in decibels at 6 different moments, CIEE Global Architecture + Design Institute for Advanced Architecture of Catalonia. Source: Vishaal Dokras + Katy Marino, Fall 2014. (update).

4 Lessons and opportunities

From the experiments conducted in these urban design studios it can be concluded that digital practices are actively providing novel methodological strategies that are deeply affecting “the depth, the relevance, and the emphasis of each stage during the design process”^v. Furthermore, they may be profoundly transforming the conceptualization of the urban and architectural practices for this new century.

The use of digital tools has proved to be highly significant during all project stages: analysis, design and representation. To identify and propose suitable digital design tools for implementation in the context of current or future architectural design studios seems to be critical, as it establishes new workflows and methodologies.

During the analysis phase, site information was collected through a variety of tools and apps widely available, proving a broader range of tools available for

architectural and urban research. The use of digital tools allows for the detection of phenomena that may be invisible to the naked eye, was enabling students to generate, to process and to understand data. Dynamic mapping techniques allowed the representation of fluctuations over time, introducing the fundamental concept of real time data. The conceptual implications of this process radically questions traditional analysis methods based on “perception”, and highlights practices based on “scientific” data. In addition, precise site-related information allows the students to distance themselves from the concept of averages and generalizations that were prevalent throughout the last century.

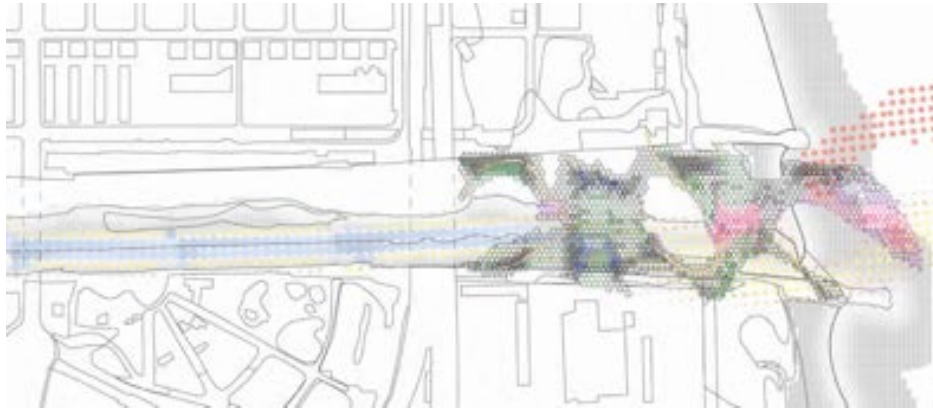


Figure 8: Design Stage showing site plan with the deployment strategy. Topological performance venues and recreational areas enable users to experience the Besos river close and from different levels. CIEE Global Architecture + Design, Institute for Advanced Architecture of Catalonia. Source: Tony Zhang, Fall 2014.

During the design stage, students exhibited more awareness about environmental aspects in metabolic systems due to the study of precise phenomena using digital tools. Their use facilitated time-based solutions where responsiveness of design systems able to react to stimuli were explored, allowing the production of customized, site-related responses (Fig. 8), and the linking with existing networks (social, urban, informational). This methodology allowed students to think systemically and to engage with existing conditions in terms of data gathering, system design, and production processes. Although this approach may have a pre-assumed condition that solutions must respond to environmental phenomena, considered by some students to be highly prescriptive, new concepts relating environmental phenomena with urban and architectural interventions quickly emerged (Fig. 9).

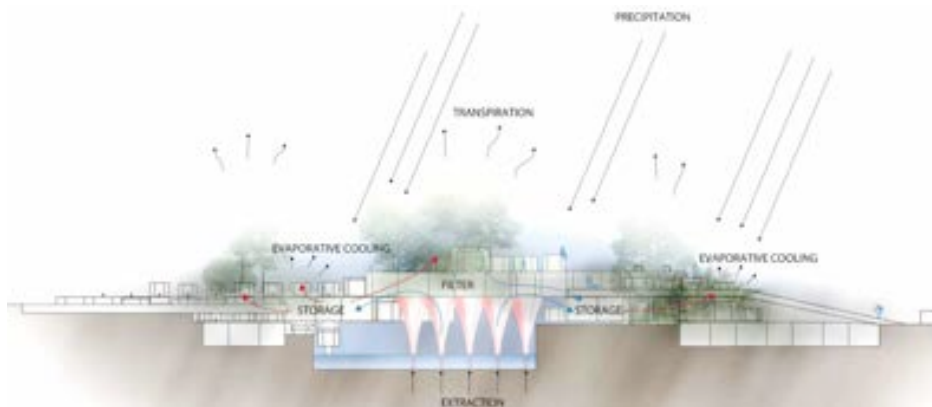


Figure 9: Design Stage showing site deployment strategy. Section of the metabolic systems proposed around waterflows in the Besos river. CIEE Global Architecture + Design Institute for Advanced Architecture of Catalonia. Source: Tony Zhang, Fall 2014.

Software skills proved to be highly influential on the results obtained for each project. Highly skilled students were able to deepen their research and reach a higher level of resolution for their projects. Intermediate skill users were able to develop their proposal, learn new software and apply new methodologies. Low skill students exhibited the greatest difficulty in the design development stage, and struggled to develop their project at an acceptable level requiring additional support from faculty. However, they showed the most improvement, and the newly acquired skills were extremely valuable throughout the process. It was also observed that some students used a mixed technique of both digital and analogue tools, a strategy that proved to be highly beneficial for their project development. Conceptually, the use of digital tools proposes a different workflow and emphasis for each project, and each student had to design their own workflow for each project stage that was customized to their particular conditions. While the experience shows positive aspects and potentials, some problems and inconsistencies also appeared related to the embedment of digital tools into pedagogical architectural studios. During the development of the studios, it was observed that most time was spent on mastering skills and tools rather than in design phase. The quick immersion into digital tools allowed exploring different design strategies, but may be insufficient to develop a complete project proposal. Other issues include the lack of familiarity of faculty about the new technologies and its advancement (both theoretically and methodologically), the inexistence of relevant design architectural references; the lack of protocols established to link new data into existing systems, are among the problems observed during this study.

The limitations observed during the analysis stage are manifold. Quantitative data was more prevalent than qualitative aspects, due to the fact that qualitative aspects are more difficult to analyze, collect, and process. The availability of suitable digital tools available to gather information, and the lack of available local data proved to be a highly limiting factor. Site collected data seems quite constant and often subject to seasonal fluctuations over time, therefore making it impossible to implement during the duration of the 3-month studios.

Most projects reported difficulties relating the data collected with the implementation of the design solution, mainly due to the lack of referents available about time based design. The solutions were highly speculative, without strong references in the realm of architecture and urban planning.

Most solutions used responsiveness based on sensors, where technology is at the center of the solutions explored, which has been criticized as techno-idolatry (Framptom, 2014). However, a number of projects proposed low tech responses based on natural flows and positively engaged with social processes.

Other questions evident from this experience include the universality of solutions since the phenomena can be present in other places, as well as the fact that solutions must consider other factors (social, cultural, etc). Also, the unclear relationship between data and the implementation of design solutions is still under evaluation, the use and abuse of the form making capacity of software to generate forms resulting in a design ingenuity, the "*software did it*" syndrome which limits forms to the capacity of the software to generate it, the clarification of how this layer can add new dimensions to the urban phenomena rather than translating immediately into "form", etc.

There is still much to research in regards to the embedment of digital tools into “advanced” architectural education because their protagonism will likely continue to expand in the near future. Their extensive use could be explained because the previous models do not work any longer, and new design processes need to be explored according to new prevailing paradigms. The challenges are manifold, and these practices should be further explored because of their capacity to question the basis of education, practice, and the conceptualization of architecture.

i Castells, Manuel. 2002. *The Information Age: Economy, Society and Culture. Vol. I: The Rise of the Network Society*. Second Edition. Oxford, UK: Blackwell Publishing.

ii Gausa et al. 2003. *The Metapolis Dictionary of Advanced Architecture*. Barcelona: Actar Publishers. Pag.34-37.

iii For details see <http://www.ciee.org/study-abroad/spain/barcelona/global-architecture/>

iv The Smart Citizen kit was “developed by Fab Lab Barcelona and IAAC that contains several sensors that monitor and collect data based on geolocation, the Internet, and free hardware and software. The device collects data for temperature, humidity, light, noise, CO and NO2 levels.”

v Woodbury, R.: 2010. *Elements of Parametric Design*, London: Routledge, Page 1-5.